

# **Wildlife and Public Access Study**

An Ecological Investigation sponsored by the San Francisco Bay Trail Project

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## **Preliminary Findings: 2 Years of Field Research from the Wildlife and Public Access Study**

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### **BACKGROUND**

The Wildlife and Public Access Study is a scientific investigation of the potential effects of non-motorized, recreational trails on shorebirds and waterfowl that use mudflat foraging habitat adjacent to the San Francisco Bay Trail. The specific objectives of the study are to assess the potential effects of human trail use on the diversity, abundance and behavior of shorebirds and waterfowl in the San Francisco Bay. Trail designers and managers may find the results useful in avoiding or minimizing human impacts on bird species.

Data were collected for 24 months at paired trail and non-trail (control) sites in three locations around the San Francisco Bay: Bothin Marsh in Mill Valley (Marin County), Redwood Shores (San Mateo County) and Shoreline at Mountain View (Santa Clara County). Year 1 data collection occurred between July 1, 1999 and June 30, 2000. Year 2 data collection occurred between October 1, 2000 and September 30, 2001. In Year 2, the control quads were moved to a new, but nearby site at each location. The trail quad remained in the same place. Having different control quads the second year is designed to provide more statistical power to the analyses. At each of the three locations, man-made levees

exist next to a tidal wetland where mudflat is exposed at low tide. The three locations were chosen because each had a control site with a levee but no official trail within one half mile of a trail site. The six sites were ecologically similar, with similar percent vegetation cover, mudflat topography and little to no buffer vegetation between the observation location (trail) and mudflat. Each trail was at least 10 feet wide with a solid, compacted surface and each was identified on the San Francisco Bay Trail Project maps. The inboard edge of each of the study quadrants was located no more than 30 feet from the edge of the trail and the levee was elevated no more than 10 feet from the mudflat.

Observations were made at each trail and control site four times a month, on two weekend days and two weekdays, for 4-hour observation periods during comparable times of the tidal cycle. Observations occurred at fixed 100-foot by 100-foot study quadrants. On designated observation days at each location, two observers collected data at the trail site while two others collected data at the control site during the same point in the out-going tidal cycle. Thus, a full team of four people was in the field at each location on each observation day. Observers sat quietly in low chairs on the levee outside

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the study quadrant during data collection. To minimize the impact of our observers on bird behavior we considered using blinds. However, consultation with shorebird experts at the Point Reyes Bird Observatory indicated that blinds were not necessary for collecting reliable data. In fact, Point Reyes Bird Observatory staff indicated that blinds would likely have been a greater disturbance than two seated, quiet observers. Furthermore, since there were always two observers during each data collection session, the impact from the observers at all sites was the same. Observers arrived at the study sites fifteen minutes in advance of the observation in order to minimize impact on the data. The study required 21 observers directed by three site supervisors, one supervisor per site. A full discussion of the study design, site selection, and data collection were provided in two reports to the San Francisco Bay Trail Project (Proposed Research Plan, 1996 and Site Selection Report, 1998).

This report provides preliminary findings from two years of summary data collected for the study. The findings are based solely upon summary data of the total number of people, total number of birds (abundance) and total number of bird species (species diversity) counted during each 4-hour observation period. For example, trail user summary data are daily totals of all people counted in half-hour intervals for the 4-hour observation period (raw data). For birds, the raw data are the number of birds and number of species counted at five-minute

intervals during the observation period. The summary data are the sum of the data collected at each five-minute interval over four hours. Therefore, the results presented here are based on only one view of the data. Many more analyses will be conducted, with both summary data and raw data, to evaluate factors such as which bird species use the different sites, as well as the effects of daily and seasonal variation.

Statistical comparisons were made using t-Tests (at alpha level 0.05) because this study was designed to meet the assumptions of this simple, but effective statistical method. The t-Test is known for its robustness and is often used to test hypotheses that rely on field data. Bird abundance and diversity data were log transformed for the t-Test analyses. See Appendix 1: 24-Month Summary Statistics for the summary of the t-Test results.

## TRAIL USE

This study was designed to compare and analyze two trail use scenarios in which levels of human trail use differed significantly: 1) weekday versus weekends at the trail sites and 2) control versus trail sites. Analysis of the two years of data showed that, at all three locations, there were significantly more visitors on weekends than weekdays at the trail sites and trail sites had statistically significant greater human use than the control sites (See *Figures 1 and 2 and Appendix 1*). Figures 1 and 2 indicate that the average number of trail users recorded during

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the 4-hour observation periods was amazingly consistent between the two years. For example, at Bothin the first year's average use at the trail (weekdays and weekends combined) was 541 people per 4 hours and in the second year it was 544 per 4 hours. The two-year combined average was 543 people.

The data showed that trail use was significantly higher on weekends versus weekdays at all three trail locations for each year separately and for the years combined (See *Figure 1*). The two years of combined data (*Figure 1c*) show that Bothin Marsh trail use more than doubled from an average of 299 people in 4 hours on the weekdays to 788 on the weekends. Shoreline trail use more than doubled from an average of 112 people in 4 hours on weekdays to 279 people on the weekends. Redwood Shores trail use was up 50% from 40 to 66 people on weekends versus weekdays.

Comparing control and trail sites, Bothin Marsh had approximately 1 visitor/day (during the 4-hour observation period) at the control site and an average of 543 visitors/day (weekend and weekday combined average) at the trail site. Shoreline at Mountain View (Shoreline) had approximately 1 visitor/day at the control site and an average of 195 visitors/day at the trail

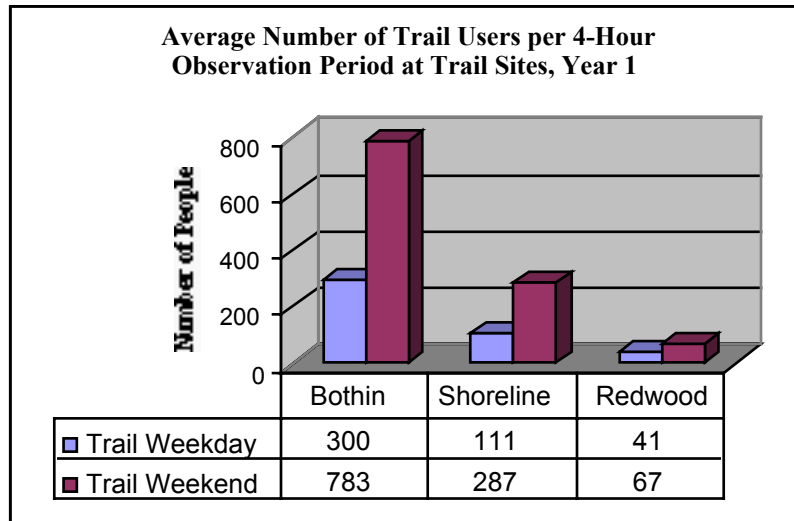
site. Redwood Shores had approximately 7 visitors/day at the control site and an average of 53 visitors/day at the trail site (*Figure 2*). These results show that the study operated as designed and the differences in human trail use patterns allow for an investigation of how trail use levels may affect shorebird and waterfowl diversity, abundance, and behavior.

This study collected data on the type and intensity of recreational use at the three locations. These data will be analyzed in the future and may prove useful to resource managers who are trying to accommodate multiple trail uses at their sites. In general, bicycling and jogging were important uses at Bothin, walking and jogging at Redwood Shores, and biking and in-line skating at Shoreline. The Shoreline uses are especially interesting since Shoreline changed its policies several years ago to allow in-line skating. It appears that there was significant demand in the South Bay for this relatively new trail use. Analyses may also provide insight into general patterns of bird activity in relation to dominant trail uses at the different sites.

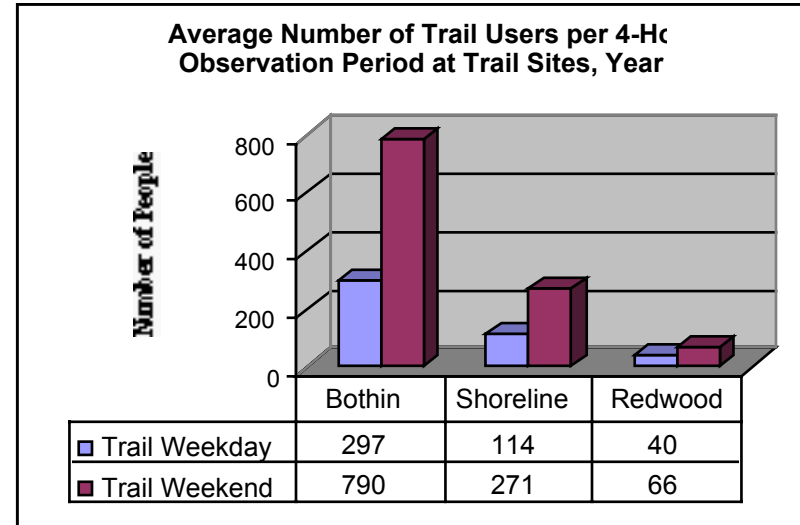
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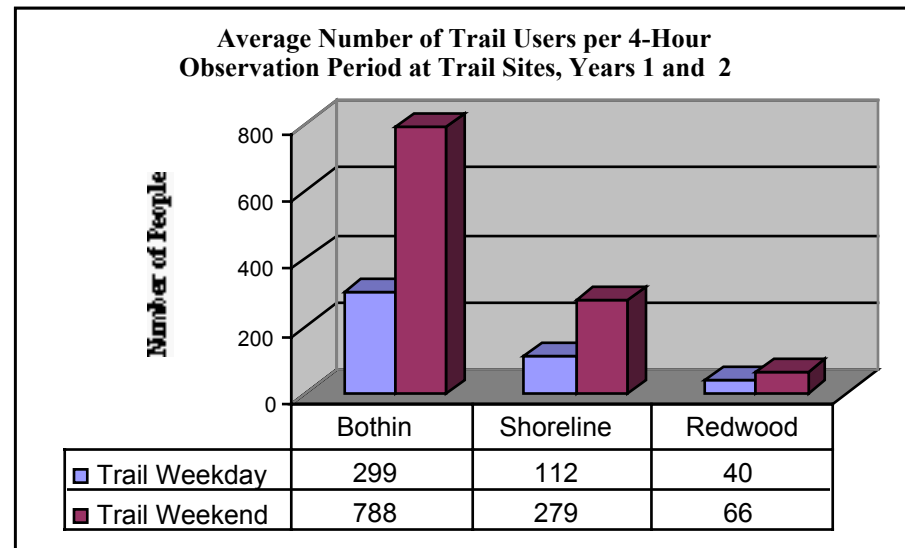
Figure 1 - Preliminary Trail User Analyses for Weekday vs. Weekend at Trail Sites



A



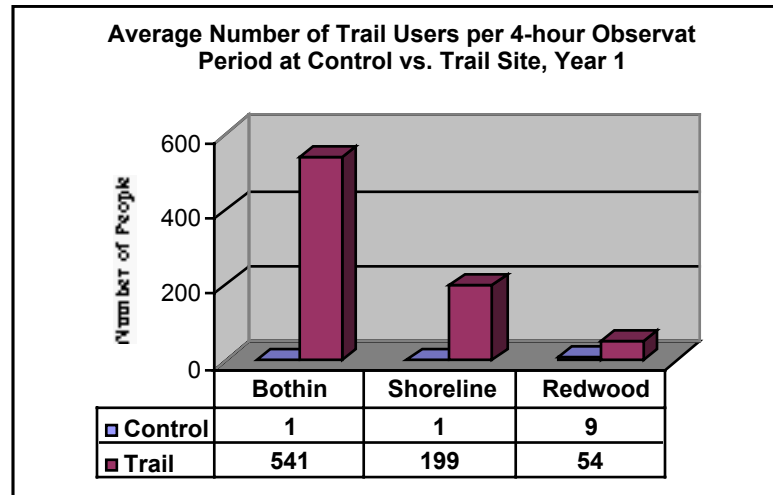
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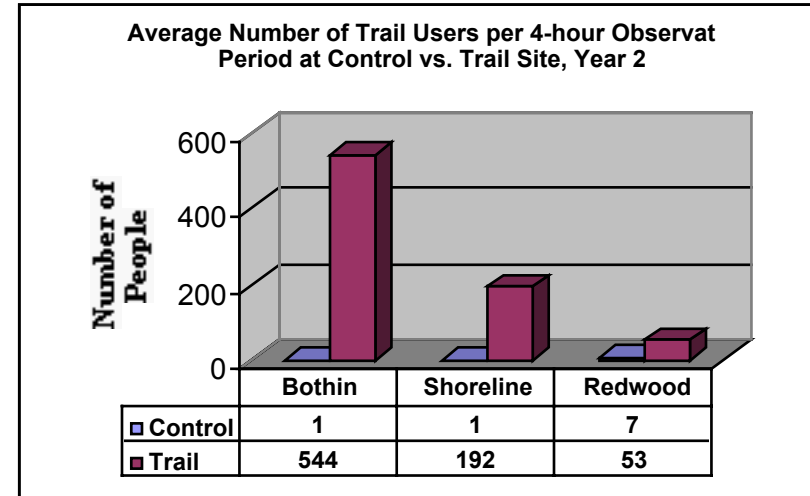
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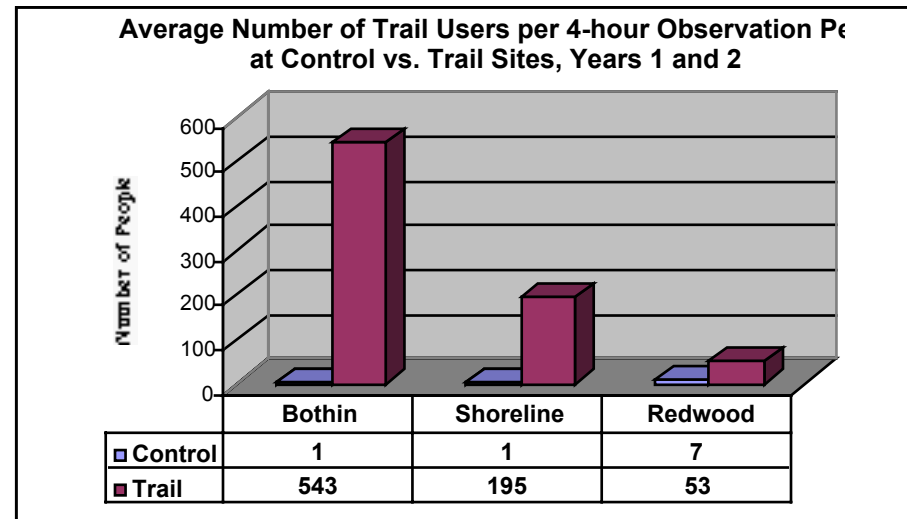
Figure 2. Preliminary Trail User Analyses for Control vs. Trail Sites



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## BIRD ABUNDANCE

**Weekdays vs. Weekends at Trail Sites.** Comparing bird use during weekdays versus weekends at the trail site is a very strong test. Since the same location is always observed, habitat conditions during the two days are nearly the same and trail use should be one of the only major differences. If human trail use were a significant impact, bird abundance would be expected to be lower during the high human use weekends versus the low use weekdays. However, although human use at each trail site was significantly higher on weekends versus weekdays, none of the sites showed a statistically significant difference in bird abundance for either year or for the years combined. The means for bird abundances are given in *Figure 3*.

Although weekday versus weekend abundances were not *statistically* different, we looked at the differences that do exist to see if they revealed a pattern. Table 1 shows that there were relatively large differences in bird numbers between weekdays and weekends at the trail sites, but that there was no pattern to the differences. At Bothin Marsh in Year 1, more birds were observed during weekdays than on weekends, but in Year 2 more birds were observed at the trail site on the *weekends* over weekdays.

The overall pattern was reversed at Shoreline where more birds were observed during the weekends in Year 1

and more on *weekdays* over weekends in Year 2. At Redwood Shores, more birds were seen on weekdays in both years.

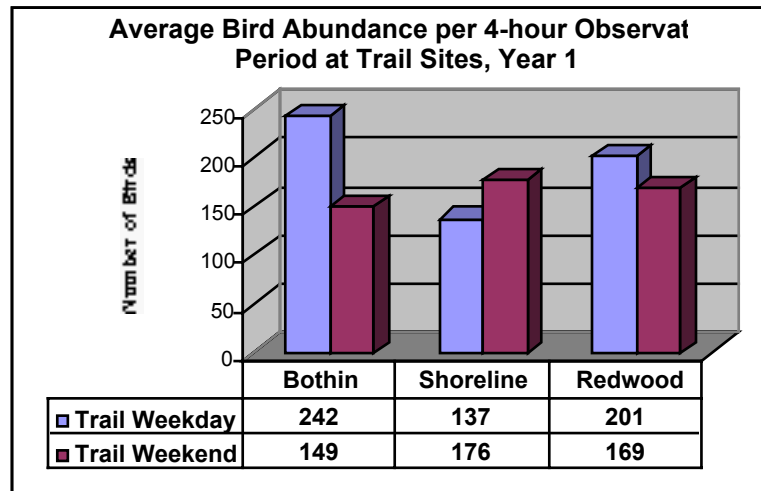
**Control vs. Trail Sites.** When comparing bird abundance at control sites versus trail sites, data from weekdays and weekends were combined. Since human use is significantly higher at trail sites over control sites, bird use might be expected to be lower at trails and higher at control sites. However, the statistical comparisons revealed no consistent pattern from the three locations (*See Figure 4*). At Bothin Marsh, the busiest of the three trail locations, the bird numbers at trail and control sites were not significantly different in either year. Bird abundance was higher at the Shoreline control site over the trail site in Year 1, but was significantly higher at the trail site in Year 2. At Redwood Shores, there was no significant difference between sites in Year 1, while there were significantly more birds at the control site in Year 2.

In Year 2, the control site quads were moved to new locations. Since human use levels at the locations were the same in the two years, it seems that differences in bird abundance patterns from the first year are more likely due to habitat differences between the two control quads than to changes in human use levels.

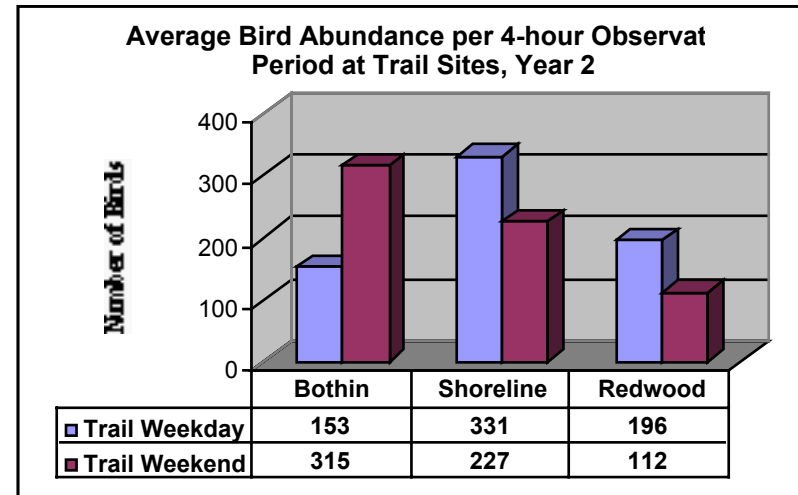
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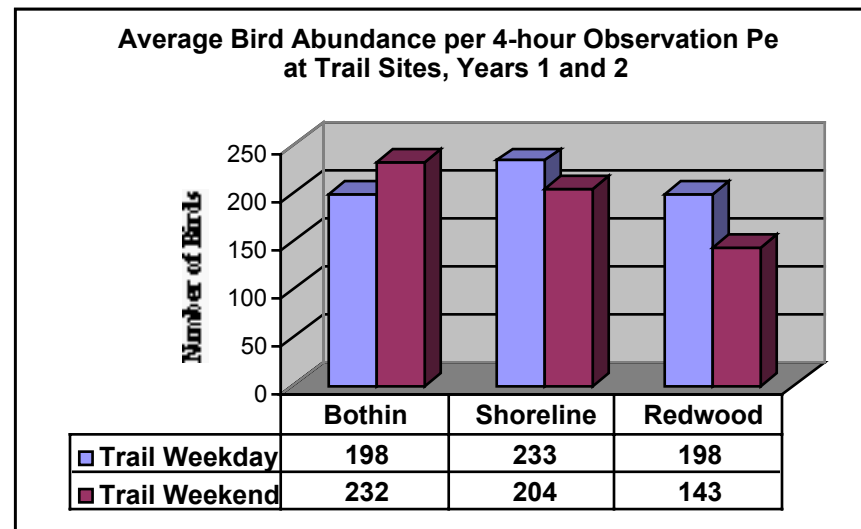
Figure 3. Preliminary Bird Abundance Analyses for Weekday vs. Weekend at Trail Sites



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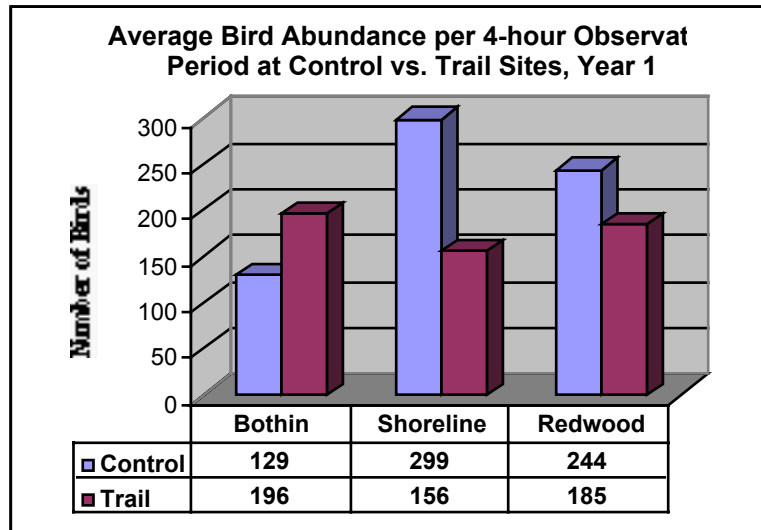


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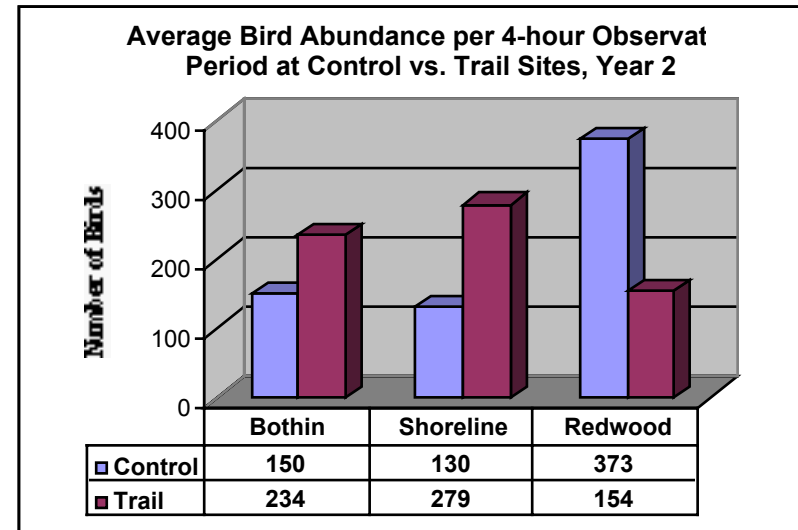
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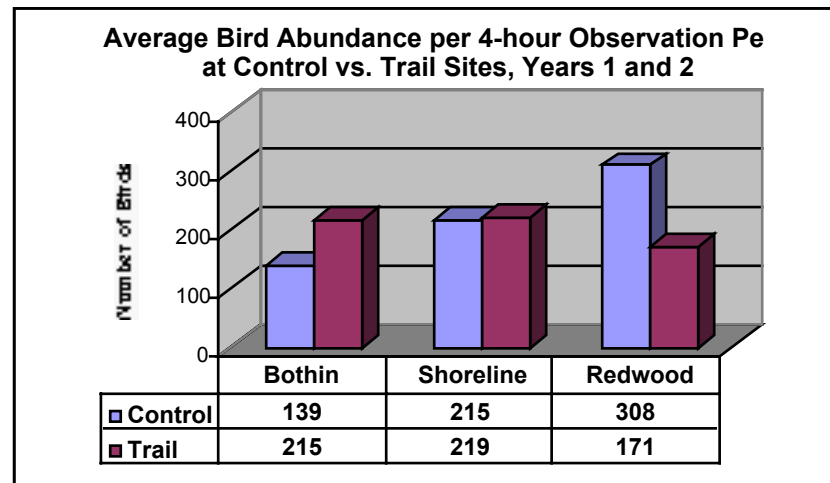
Figure 4. Preliminary Bird Abundance Analyses for Control vs. Trail at Trail Sites



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Examining the bird abundance differences, even though some were not significant, does not provide a clear pattern. Table 1 shows that the Bothin trail site had 34% and 36% more birds than the control site in Year 1 and Year 2, respectively. At Shoreline, the pattern was split—more birds at the control site the first year, more birds at the trail site the next year. At Redwood Shores, more birds were seen at the control site both years.

Overall, bird abundance analyses showed no clear pattern with respect to human trail use. Further analysis of bird numbers will evaluate the effects of seasonality, daily events and other subtle factors. In addition, future analyses will examine the reactions of individual species as well as classes of species (migratory, resident, guilds). Finally future work will characterize the behavior of birds during high human use versus low use conditions.

## BIRD SPECIES DIVERSITY

**Weekdays vs. Weekends at Trail Sites.** As with bird abundance, the results for bird species diversity showed no statistical difference at any of the locations for either year with respect to weekdays versus weekends comparisons (*See Figure 5*).

**Control vs. Trail Sites.** When comparing trail sites to control sites, there was no consistent pattern for species diversity shown by the three locations (*See Figure 6*). For both years and the years combined, species diversity was significantly greater at the Shoreline trail site than at the control sites. The pattern was reversed for Redwood Shores where the control sites had significantly more species than the trail site. Finally, there was no significant difference in bird species diversity at the Bothin Marsh sites.

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**Table 1. Magnitude of Differences in Bird Abundances**

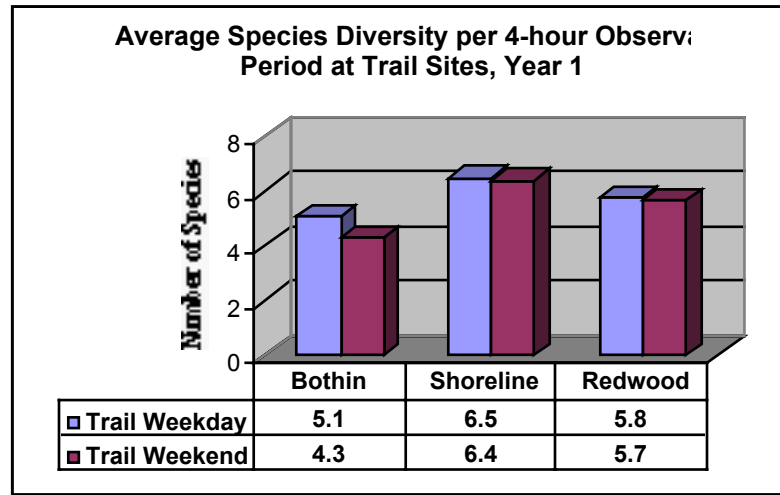
	Trail Comparisons		Trail/Control Comparisons	
	More Birds on Weekdays	More Birds on Weekends	More Birds at Control Site	More Birds at Trail Site
<b>Bothin</b>				
<b>Year 1</b>	<b>Yes--38%</b>			<b>Yes – 34%</b>
<b>Year 2</b>		<b>Yes – 51%</b>		<b>Yes – 36%</b>
<b>Shoreline</b>				
<b>Year 1</b>		<b>Yes – 23%</b>	<b>Yes – 48%*</b>	
<b>Year 2</b>	<b>Yes – 31%</b>			<b>Yes – 54%*</b>
<b>Redwood</b>				
<b>Year 1</b>	<b>Yes – 16%</b>		<b>Yes – 24%</b>	
<b>Year 2</b>	<b>Yes – 43%</b>		<b>Yes – 59%*</b>	

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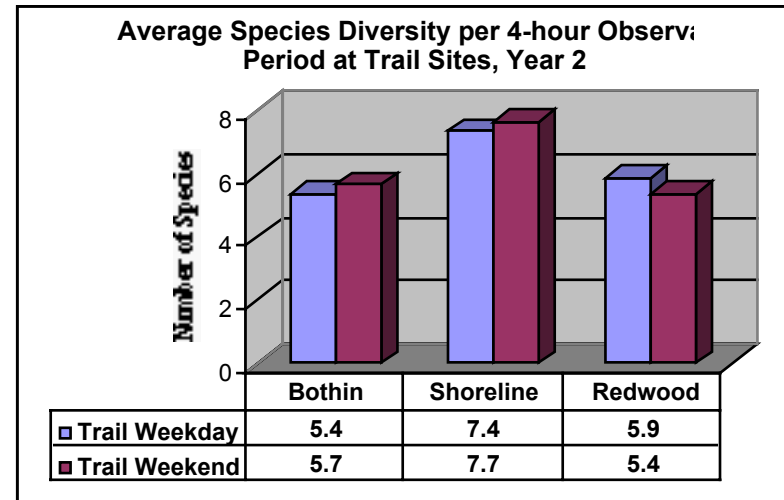
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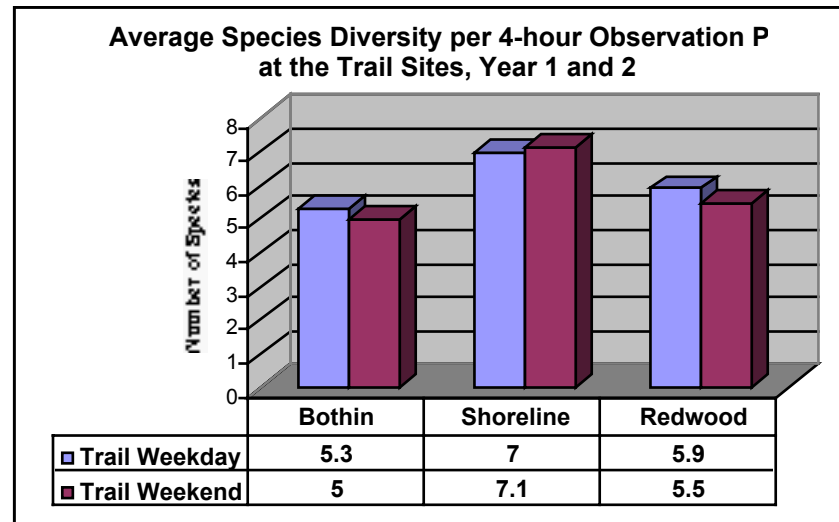
**Figure 5. Preliminary Species Diversity Analyses for Weekday vs. Weekend at Trail Sites**



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B

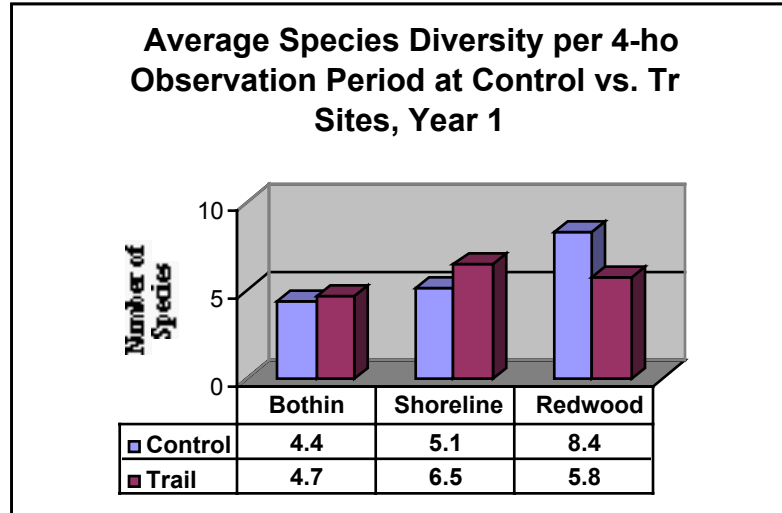


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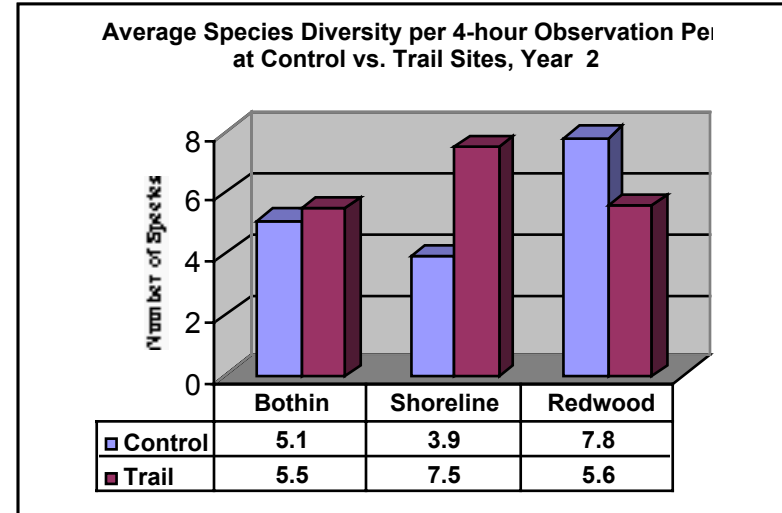
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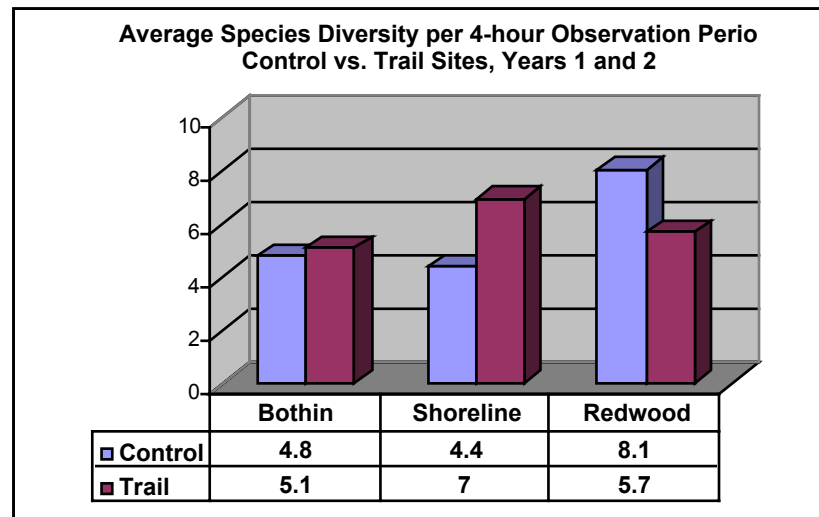
**Figure 6. Preliminary Species Diversity Analyses for Control vs. Trail Sites**



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## BETWEEN SITE/BETWEEN YEAR COMPARISONS

A more complex statistical analysis (ANOVA) was conducted to determine if there were differences between locations and between years for bird abundance. This test showed that between years, the trail sites were very similar. Also, the trail sites for the three locations were similar to each other in both years. Of 15 comparisons done in the ANOVA only 2 showed statistically-significant differences.

However, the ANOVA for the control sites showed many differences, both from year to year within locations and when comparing different locations. Of 15 comparisons for the control sites, 7 were statistically significant. The large number of differences between locations and between years may be due, in part, to the fact that the control sites were moved in the second year. Overall, the variability at the control sites may be due to habitat differences.

## CONCLUSIONS

A number of caveats must be considered when interpreting the preliminary results of this study. To date, the conclusions apply only to overall species abundance and diversity as compiled over 96 days of 4-hour observation periods. Many other measures of abundance and diversity exist and will be used in future comparisons. Relationships relative to species-specific effects, daily effects or seasonal effects have not yet been

explored in this analysis. This study examines impacts to birds in their foraging habitat. Potential effects of trail use on species abundance and diversity adjacent to breeding habitat are not a part of this study.

In addition, it should be noted that these results were collected under specific conditions and may apply only to sites with similar conditions. For example, trails were within 30 feet of the mudflat and motorized vehicles were not allowed at these sites. Changes in these conditions could produce different results. It is also important to realize that both the trail and the control sites in this study were adjacent to levees and all of these sites have been altered in other ways from their natural condition. All three locations exist in the highly developed and urbanized San Francisco Bay Area. As a result, the species composition and probably the behavior of birds have changed since Europeans arrived. Studies in pristine, undisturbed natural areas might yield different results. It is not the goal of this study to understand how trails might have affected a pristine San Francisco Bay environment. Rather, the goal is to determine whether, under today's existing conditions, trails are having a significant impact on bird abundance, diversity and behavior.

Given these qualifications, several conclusions are appropriate based on the 4-hour observation summary data collected during the 24 months of the study:

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1. The study functioned as designed, allowing for complete analyses of the research questions.
2. The second control sites, established at each location in Year 2, are proving valuable to interpreting the results. For example, the Year 2 control site at Shoreline had significantly fewer birds than the Year 1 site, while the trail site had significantly more birds the second year than the first. The pattern was reversed at Redwood Shores. These comparisons suggest differences in habitat quality at each site rather than overall changes in bird numbers that are affecting the entire region.
3. These preliminary results showed no general relationship between human use of trails and bird abundance or diversity in foraging habitats at the three locations studied in the San Francisco Bay Area. However, Redwood Shores showed a pattern of greater bird abundance and diversity at the control sites over the trail site for both years. Closer analysis of each location may reveal species found consistently only when human presence is relatively infrequent or generally low.
4. The lack of pattern exemplified both by the trail versus control findings and the weekday versus weekend results suggests that habitat quality may be a more important determinant of bird use than human trail use.

## FUTURE ANALYSES

Further more detailed analyses of this data will evaluate the relationships that may exist between human trail use, bird use, bird behavior, seasonal variations and daily variations to reach a fuller understanding of the effect of trail users, if any, on foraging water birds. Statistical and qualitative analyses will also be conducted to assess the potential effects of trail use on particular species of birds and/or classes of birds (such as migratory versus resident species). Currently, the raw data are being entered into a database that will allow for more complex analyses. Results from this work may suggest directions for further analysis and direction for future studies.

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## THANK YOU

Thanks to the following funders who have enabled us to conduct this groundbreaking field research:

Bay Trail Project  
California Coastal Conservancy  
California Trails & Greenways  
Foundation  
Cargill Salt Company  
East Bay Regional Park District  
National Park Service  
Oracle Corporation  
Vandenberg/Lipton  
Varian Foundation  
Midpeninsula Regional  
Open Space District

Thanks to the following people for their technical assistance in designing the study and the data collection forms, developing the statistical tests, and evaluating the statistical findings:

Bill Bousman, Santa Clara Valley Audubon Society  
Shannon Bros, San Jose State University  
John Geibel, Department of Fish and Game  
Philip Law, Department of Fish and Game  
Lynne Stenzel, Point Reyes Bird Observatory

Thanks to the following people and organizations for their assistance in establishing the study sites:

Joy Albertson, US Fish and Wildlife Service  
David Hansen, Marin Open Space District  
Lori Johnson, Cargill Salt Company  
Glenn Lyles, City of Mountain View  
Teresa Le Blanc, Department of Fish and Game  
Clyde Morris, US Fish and Wildlife Service  
Rick Parmer, Department of Fish and Game  
Stephen Petterle, Marin Open Space District  
Jill Singleton, Cargill Salt Company (now at EBRPD)  
Chuck Taylor, Cargill Salt Company  
Peter Vorametsanti, Redwood City

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## Appendix 1: Year 1 Summary Statistics<sup>1</sup>, July 1, 1999 to June 30, 2000

<i>Location</i>	<i>Site</i>	<i>Weekday vs. Weekend</i>			<i>Control vs. Trail Sites</i>		
		<i>Trail Users</i>	<i>Bird Abundance</i>	<i>Species Diversity</i>	<i>Trail Users</i>	<i>Bird Abundance</i>	<i>Species Diversity</i>
<b>Bothin Marsh</b>	Trail	<b>S</b>	<b>NS</b>	<b>NS</b>	<b>S</b>	<b>NS</b>	<b>NS</b>
		Xd=299.6	Xd=242.3	Xd=5.1	Xc= 0.6	Xc=128.8	Xc=4.4
		Xe=783.2	Xe=148.7	Xe=4.3	Xt=541.4	Xt=195.5	Xt=4.7
	Control	<b>NS</b>					
		Xd=0.2					
		Xe=1.1					
<b>Shoreline</b>	Trail	<b>S</b>	<b>NS</b>	<b>NS</b>	<b>S</b>	<b>NS-S</b>	<b>S</b>
		Xd=110.6	Xd=136.5	Xd=6.5	Xc= 0.7	Xc=299.1	Xc=5.1
		Xe=286.8	Xe=175.6	Xe=6.4	Xt=198.7	Xt=156.0	Xt=6.5
	Control	<b>NS</b>					
		Xd=0.8					
		Xe=0.7					
<b>Redwood Shores Trail</b>	Trail	<b>S</b>	<b>NS</b>	<b>NS</b>	<b>S</b>	<b>NS</b>	<b>S</b>
		Xd=41.2	Xd=200.8	Xd=5.8	Xc= 9.0	Xc=243.5	Xc=8.4
		Xe=66.5	Xe=168.5	Xe=5.7	Xt=54.3	Xt=184.7	Xt=5.8
	Control	<b>S</b>					
		Xd= 6.3					
		Xe=11.7					

*1 – Significance determined using t-Tests for equal variances performed on log transformed data; the means presented are the actual means, not log transformed.*



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## Appendix 1: Year 2 Summary Statistics<sup>1</sup>, October 1, 2000 to Sept. 30, 2001

<i>Location</i>	<i>Site</i>	<i>Weekday vs. Weekend</i>			<i>Control vs. Trail Sites</i>		
		<i>Trail Users</i>	<i>Bird Abundance</i>	<i>Species Diversity</i>	<i>Trail Users</i>	<i>Bird Abundance</i>	<i>Species Diversity</i>
<b>Bothin Marsh</b>	Trail	<b>S</b>	<b>NS</b>	<b>NS</b>	<b>S</b>	<b>NS</b>	<b>NS</b>
		Xd=297.1	Xd=153.1	Xd=5.4	Xc= 0.6	Xc=150.1	Xc=5.1
		Xe=790.4	Xe=314.8	Xe=5.7	Xt=543.8	Xt=234.0	Xt=5.5
	Control	<b>NS</b>					
		Xd=0.33					
		Xe=0.92					
<b>Shoreline</b>	Trail	<b>S</b>	<b>NS</b>	<b>NS</b>	<b>S</b>	<b>S</b>	<b>S</b>
		Xd=113.9	Xd=331.2	Xd=7.4	Xc= 0.8	Xc=129.8	Xc=3.9
		Xe=270.5	Xe=227.3	Xe=7.7	Xt=192.2	Xt=279.2	Xt=7.5
	Control	<b>NS</b>					
		Xd=0.67					
		Xe=1.0					
<b>Redwood Shores</b>	Trail	<b>S</b>	<b>NS</b>	<b>NS</b>	<b>S</b>	<b>S</b>	<b>S</b>
		Xd=39.6	Xd=195.7	Xd=5.9	Xc= 5.9	Xc=373.2	Xc=7.8
		Xe=66.1	Xe=112.3	Xe=5.4	Xt=52.9	Xt=154.0	Xt= 5.6
	Control	<b>S</b>					
		Xd=3.0					
		Xe=9.0					

1 – Significance determined using *t*-Tests for equal variances performed on log transformed data; the means presented are the actual means, not log transformed.

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## Appendix 1: 24-Month Summary Statistics<sup>1</sup>

<i>Location</i>	<i>Site</i>	<i>Weekday vs. Weekend</i>			<i>Control vs. Trail Sites</i>		
		<i>Trail Users</i>	<i>Bird Abundance</i>	<i>Species Diversity</i>	<i>Trail Users</i>	<i>Bird Abundance</i>	<i>Species Diversity</i>
<b>Bothin Marsh</b>	Trail	<b>S</b>	<b>NS</b>	<b>NS</b>	<b>S</b>	<b>NS</b>	<b>NS</b>
		Xd=298.9	Xd=197.7	Xd=5.3	Xc= 0.7	Xc=139.4	Xc=4.8
		Xe=787.6	Xe=231.8	Xe=5.0	Xt=543.2	Xt=214.7	Xt=5.1
	Control	<b>NS</b>					
		Xd=0.38					
		Xe=1.1					
<b>Shoreline</b>	Trail	<b>S</b>	<b>NS</b>	<b>NS</b>	<b>S</b>	<b>NS</b>	<b>S</b>
		Xd=112.2	Xd=233.8	Xd=7.0	Xc= 0.8	Xc=214.6	Xc=4.4
		Xe=278.6	Xe=204.0	Xe=7.1	Xt=195.4	Xt=218.9	Xt=7.0
	Control	<b>NS</b>					
		Xd=0.71					
		Xe=0.83					
<b>Redwood Shores</b>	Trail	<b>S</b>	<b>NS</b>	<b>NS</b>	<b>S</b>	<b>S</b>	<b>S</b>
		Xd=4.2	Xd=198.2	Xd=5.9	Xc= 9.0	Xc=308.3	Xc=8.1
		Xe=66.4	Xe=143.5	Xe=5.5	Xt=54.3	Xt=170.8	Xt=5.7
	Control	<b>S</b>					
		Xd=4.38					
		Xe=10.21					

1 – Significance determined using t-Tests for equal variances performed on log transformed data; the means presented are the actual means, not log transformed.

# Wildlife and Public Access Study

An Ecological Investigation sponsored by the San Francisco Bay Trail Project

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## Key to Appendix Abbreviations

**NS** = The difference between the means is **not statistically-significant**; i.e., the two means are from the same population.

**S** = The difference between the means is **statistically significant**; i.e., the two means are from different populations.

**Xd** = **Mean of Weekday Data** (the numbers are the actual means, not the means of the transformed data)

**Xe** = **Mean of Weekend Data** (the numbers are the actual means, not the means of the transformed data)

**Xc** = **Mean of Control Site Data**, which combines weekend and weekday data (the numbers are the actual means, not the means of the transformed data)

**Xt** = **Mean of Trail Site Data**, which combines weekend and weekday data (the numbers are the actual means, not the means of the transformed data)